DOCUMENT RESUME

ED 230 584 TM 830 344

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TITLE Towards a Lakatosian Programme of Research into Concept Development.
PUB DATE Sep 81
NOTE 15p.; Paper presented at the Annual Meeting of the Oxford Science Education Conference (England, September 1981). Figure 1 contains small print.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Development; Concept Formation; *Developmental Stages; *Epistemology; Learning Processes; *Learning Theories; *Research Design; Research Methodology; Schemata (Cognition)
IDENTIFIERS *Lakatosian Programme; *Piagetian Theory

ABSTRACT

Although the ideas of Jean Piaget still dominate the field of science education, the range and severity of criticisms has increased progressively. In recent years, the emergence of a different theory of cognitive development has begun. This paper tentatively outlines a Lakatosian Research Programme for the alternative conceptions field. The fundamental assumptions on which the field could be based might be: (1) the world is real but individuals vary in their perception of it; (2) an individual's conceptions of the real world have integrity for that individual; (3) consciousness being intentional, all observations are theory dependent; (4) individuals use personally pre-existing theories to erect explanatory hypotheses about events in their environment; (5) these hypotheses are then tested for fruitfulness; and (6) the underlying theories are modified in the light of this testing. In the long term, the Program has political as well as academic overtones. If an alternative conceptions program succeeds in demonstrating a priori (i.e. using data analysis conducted without Piagetian expectations) that Piaget's "epistemic subject" does not exist, then stratified access to educational resources has no validity in science education and science education will be the more securely based. (PN)

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TOWARDS A LAKATOSIAN PROGRAMME OF RESEARCH INTO CONCEPT DEVELOPMENT

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presented at the Oxford Science Education Conference
September, 1981

Acknowledgement

We are grateful to our colleagues in the Personal Construction of Knowledge Group at the University of Surrey for their helpful comments and suggestions.

INTRODUCTION

A review of the literature on science education is likely to lead the reader to conclude that the ideas of Jean Piaget dominate the field. His work, and that of the Geneva School, apparently constitute the 'received view' for most teacher educators and, consequently, their students. A high point of acceptance was reached, for the U.K., in the mid-1960's. It was then possible to open a respected textbook on educational psychology e.g. Stones (1966) and find the Piagetian 'stages' listed, apparently as 'facts', without authorship being attributed in the index. This dominance still exists, as witnessed by the high proportion of research funding invested in his views and the number of theses that consequently appear. However, the range and severity of criticisms has increased progressively.

Many of these criticisms can be traced back to Flavell (1963) and are summarised overleaf.

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(i) the Piagetian version of clinical interview method is open to doubt. For example, the interview tasks, being conceived within a Piagetian theoretical framework, preclude attention being paid to individuals' responses alternative to those prescribed by the template.

(ii) the method has an over-dependance on the linguistic abilities of children, presuming a high correspondence between thought and verbal expression.

(iii) training, and other mediated forms of experience, can bring about, or accelerate, Piagetian cognitive structure development. This is not strongly anticipated by the theory.

(iv) the cognitive structures advanced are, in some cases, over-elaborate for a representation of the behaviour in question and, in other cases, nomothetic in outlook.

A further critique from Brown and Desforges (1979) is that the theory offers an explanation of cognitive development based on equilibration as the central mechanism of change. This is not seen to be adequate. However, it is not our intention to attempt to directly refute Piaget's views, but rather to show that his theories are sufficiently under attack to warrant discussion of alternatives.

In recent years, the emergence of a different theory of cognitive development has begun. Based on a range of allied notions variously called 'alternative frameworks' (Driver, R, Easley, J (1978)),'alternative conceptions'(Osborne R.J., Gilbert J.K. (1980)), 'preconceptions' (Ausubel (1968)), misconceptions (Helm (1980)). The approach has not been associated with any one worker but represents the existence of an 'invisible college'.

It is pre-paradigmatic, in Kuhn's (1970) sense, for the efforts of individuals have, so far, been unco-ordinated: terminology has not been agreed, appropriate methodology not accepted, ultimate aims not stated, classroom applicability not demonstrated. However, it has attracted a lot of attention e.g. Magoon (1977) and generated a fruitful contrast with Piaget's views e.g. Archenhold et al (1980).

In this paper we propose to start the long, and interactive process, of articulating this school. It is necessary to identify, at least partially, our conception of science. We consider this to be important since our programme of research embodies a view of science which is at odds with the 'traditional' one and is a modification of the views of Popper (1959) and Kuhn (1970) which are outlined in the following section.

Philosophic Antecedents to Lakatosian Science

The prevailing conception of science held by the public today still appears to be a positivist, empiricist-inductivist one. It is still recognisably based on Bacon's articulation of scientific method put forward at the beginning of the seventeenth century. In the introduction we referred to this conception as the 'traditional' view. Our observations in England tend to confirm those of Cawthron et al (1978) in Australia that the 'traditional' view still seems to be the image of science projected in schools today. Yet it has long been regarded as an inadequate account.

Popper (1959) rejected empirical-inductivism and logical positivism by advocating hypothetico deductive method and falsificationism. He pointed out that whilst a scientific law can never be conclusively verified, *it can* be conclusively falsified - a single counter instance being all that is needed.

He advises that hypotheses should be made as unambiguous as possible. The more falsifiable a hypothesis is, the more scientific it is. A hypothesis which is incapable of being falsified cannot be tested and must be regarded as unscientific. For Popper, science is 'revolution in permanence'. An investigation *begins* with a hypothesis ('conjecture') and proceeds by the deduction of testable ('refutable') consequences.

Popper proposes an 'activist' theory of knowledge in which the scientist interacts dialectically with his environment. He suggests that there is no 'pure disinterested theory free observation' - all are 'theory impregnated'. Popper believes in the existence of 'objective' knowledge, of 'real facts' independent of the world of men. He is not, however, an 'absolutist' i.e. he does not believe that truly objective knowledge is ever attainable. Science can nevertheless *progress towards* it.

Other Theorists e.g. Kuhn (1970) have continued his anti-positivist stance but have also emphasized the sociological and psychological components of knowledge. Popper rests his whole case for the rationality of science not on the logic of discovery, which remains a psychological act, but on the logic of proof by refutation. Kuhn claims that falsification is not, and cannot, be the means by which theories are chosen. He furthermore asserts that 'revolution' is neither the normal activity of science nor is it the means by which it progresses.

Kuhn argues that theories are inseparably embedded in an overall structure or 'paradigm' - the notion of paradigm shifts being a central idea advanced in his conception of science (see Figure 1 overleaf).

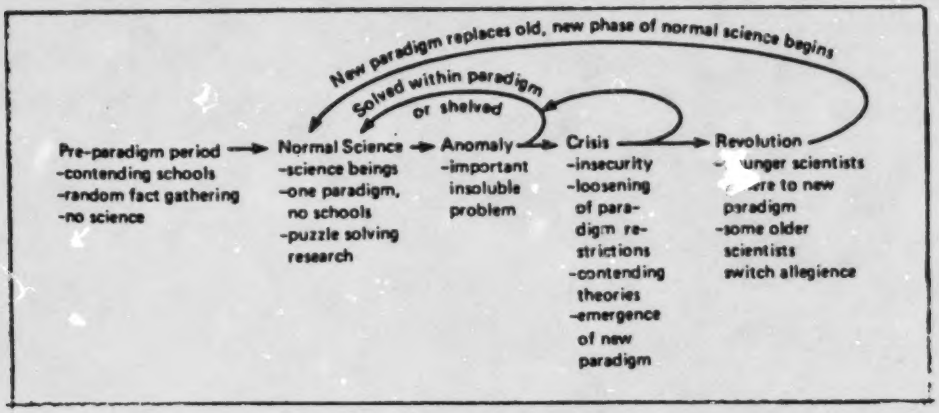

Figure 1. The Revolutionary Character of Paradigm Shifts (Kuhn 1970) (After Leahey (1980)

At any point in time the scientific community tends to share a paradigm (witness the current allegiance to Piagetian views within science education). To share a paradigm is to suspend critical discourse and commit oneself to certain fundamental postulates. A paradigm provides an agreed framework of laws, theories and methods within which to work - at least for the time being. This is what enables research to be conducted coherently and, indeed, is prerequisite for science to proceed or progress at all. A researcher who adopts the accepted paradigm practices 'normal-science' (Kuhn 1970). It is only when faced with the most recalcitrant of puzzles that the normal scientist will judge them refutations rather than anomalies. If this happens he may proceed through a period of crisis and/or revolution prior to the evolution of a new paradigm and a new period of normal science. The new and the old paradigms will represent 'incommensurable ways of seeing the world and of practising science in it". (Kuhn, 1970). An individual who adopts a new paradigm experiences a 'gestalt switch'. The 'paradigm' renders the meaning of scientific terms dependant on it. When a paradigm changes so *do the meanings of any terms carried forward.*

For Kuhn truth and progress are paradigm bound.

We suggest that two goals for theories of knowledge appear to be both desirable and necessary:

(i) to be of *use* such theories must provide heuristic *guidance*.

(ii) to be *valid* such theories must be *real* (in the face of historical evidence).

These goals frequently tend forward mutual exclusion. Thus Popper's account is eminently clear with respect to (i) but less plausible as regards (ii). The reverse has been claimed for Kuhn.

Lakatos (1970) attempts to provide what we think is an appealing approach to this problem. He advances what amounts to a compromise between these two authors: In sympathy with Kuhn's notion of a paradigm, Lakatos' 'research programme' denies the possibility of appraising single theories in isolation. He likewise argues that "science can grow without any 'refutations' leading the way". He is, however, in agreement with Popper when he argues that there are principles by which a theory may be chosen *objectively*.

For Lakatos, the main advantages of a research-programme are that it affords guidance and a degree of autonomy for those engaged in it. It is through research-programmes that science grows and through their relative success that science progresses.

Lakatos' Notion of a Programme of Research

Lakatos' central notion of a research programme has been summarised by Papineau (1979) as overleaf.

> "A research programme is an evolving succession of theories. Such a research programme is characterized by a *negative heuristic* and a *positive heuristic*. The *negative* heuristic of the programme derives from a methodological decision to regard certain fundamental theoretical assumptions as effectively irrefutable. These fundamental assumptions form the *hard core* of the programme, and their inviolability means they are common to each of the evolving succession of theories that make up the programme. Each of these succeeding theories is a *version* or *variant* of the programme. They differ in the differing sets of *auxiliary hypotheses* that they conjoin to the fundamental assumptions of the hard core. Such auxiliary assumptions will in general serve to 'pin down' the entities discussed in the hard core in such a way as to make it possible to derive specific predictions from a particular version of the programme. If such a prediction is not borne out then we have an *anomaly*. But this will reflect in the first instance not on the research programme as a whole but only on the particular version which gave rise to the confuted prediction. Because the hard core has been rendered irrefutable by methodological fiat, it will always be the auxiliary hypotheses peculiar to that version that are replaced rather than the fundamental assumptions which define the programme itself. Thus the programme generates a succession of variations on the common theme of the hard core, each successive version producing adjusted sets of auxiliary hypotheses to replace those of the previous version. The *positive* heuristic of a programme consists of a partially articulated set of suggestions or hints on how to change, develop the 'refutable variants' of the research programme, how to modify, sophisticate, the 'refutable' protective belt. That is, the positive heuristic guides scientists when they want to move from one version of a research programme to a later improved one - it tells them what kinds of modifications in their protective belt of auxiliary hypotheses are appropriate".

A research programme can be described as being 'progressive' or 'degenerate'. A truly progressive programme has to be both *theoretically* progressive i.e. has to account for all the consequences of the previous theory and add novel predictions, and to be *empirically* progressive i.e. at least some of those novel predictions must be confirmed. A really degenerate programme consistently fails to lead to the discovery of novel phenomena. Thus for an 'alternative conceptions' programme to displace a 'Piagetian' programme it would have to be judged to be more progressive.

Alternative-Conceptions within a Lakatosian Research Programme

We will now attempt to outline a Lakatosian Research Programme for the alternative conceptions field.

The 'hard core' of the negative heuristic i.e. the fundamental assumptions on which the field could be based might be

(i) the world is real but individuals vary in their perception of it

(ii) an individuals conceptions of the real world have integrity for that individual

(iii) consciousness being intentional, all observations are theory dependent.

(iv) individuals use personally pre-existing theories to erect explanatory hypotheses about events in their environment.

(v) these hypotheses are then tested for fruitfulness

(vi) the underlying theories are modified in the light of this testing

Some illustrative auxiliary hypotheses, which function as a 'protective belt' i.e. enable specific predictions to be made, are correspondingly

(i) an individuals questions will tend to fall into one of a small number of distinctive possibilities

(ii) the consideration of two or more hypotheses in relation to one event constitutes a form of testing

(iii) an hypotheses is fruitful if it overtly links explanation of past events to predictions for future events

(iv) the perceived attributes of a concept govern the use to which that concept is put

(v) an individual's conception of the real world are linked by a form of logic

From their very definition, anomalies can only arise after the auxiliary hypotheses have failed. Thus they can only be stated when the Programme has been carried out. However, it is possible to predict the sort of thing which would constitute an anomaly. An example would be if *no* logical links between an individual's conceptions were demonstrated by a number of separate workers.

The positive heuristic i.e. those research activities whose outcomes might direct the modification of the protective belt, could include attempts

(i) to alter the apparent levels of inclusion of possible conceptions

(ii) to show that an individual ***uses*** only one of two or more known, and equally applicable, hypotheses in the explanation of an event

(iii) to show that an hypothesis accepted on external authority is incapable of linking past and future events

(iv) to show that the perceived attributes of a concept could not be changed for an individual

(v) to demonstrate that a concept had been learnt incidentally.

Alternative Conceptions Methodologies

The methods chosen to develop the positive heuristic should reflect the fundamental assumptions of the 'hard core'. The 'hard core' outlined in this paper adopts an epistemological position similar to that of Kelly (1955) - i.e. the notion of constructive alternativism. Similarities between Kelly's views of science and those of Popper and Kuhn have been discussed by Pope and Keen (1981) and they have described various Repertory Grid Techniques which have evolved from Kelly's work and which are methods consistent with the basic assumptions of the 'hard core' of our research programme.

The Interview-about-Instances (I.A.I.), (Osborne & Gilbert (1980)) technique has been the most frequently used method by members of the Personal Construction of Knowledge Group at the Institute for Educational Technology, University of Surrey. Like the Repertory Grid - the I.A.I. is a technique for exploring an individual's view of the world in his/her own terms. Pope (1981) also outlines the Illuminative Incident Analysis (Cortazzi & Roote (1975)) and points to the relevance of Terhart's Hermeneutic approach (Terhart 1981) as further examples of methods compatible with the philosophical stance of the Personal Constructions of Knowledge Group.

Future Perspectives for an Alternative-Conceptions Programme

The production of a Lakatosian Programme for the alternative conceptions field, tentatively outlined above, engenders a variety of challenges for all those interested in the field. These can only be met over an extended time scale, even assuming that adequate finance is forthcoming.

In the short term, teachers must be made aware of the central ideas. A Workshop 'From Children's Science to Scientists' Science' (Gilbert, J.K., Osborne, R.J. (1980)) has been produced in three versions and run with a variety of pre-service and in-service teacher participants. Whilst the balance of involvement can be moved from researcher to teacher the latter becoming part-time research students, a more fundamental shift is called for. Organisations like the Classroom Action Research Network, co-ordinated from the University of Cambridge, Institute of Education seems an appropriate model. The 'Personal Construction of Knowledge Group' at the University of Surrey, and the 'Science Education Research Unit at the University of Waikato, New Zealand, are moving in that direction.

Conferences, like that reported in Archenhold (et al) (eds) (1980), will provide a focus for discussion. Attempts are now being made to establish a Special Interest Group within the American Educational Research Association: currently referred to in terms of the field of 'cognitive structure' (to cater for the local linguistic preferences).

In the medium term, those aspects of the Programme which address 'classroom implications' must be tackled. Teachers often ask questions like:

'does this mean that science teaching has to be re-arranged?

'how can I find the time?'

'most children won't ever be interested in science'

'you've got to have discipline to start with'

These perennial questions will have to be specifically answered. Tied to those replies must be an adequate response to the assertion that "Even the most wonderful teaching programme would be largely spoiled...if it had to be tied to examinations that did not fit its method or spirit".

(Nuffield, 'O' Phy. T.G.I. (1966))

In the long term, the Programme has political as well as academic overtones. Unless reliable methods for 'cognitive acceleration' can be found, the Piagetian model implies a stratified access to educational resources, for as Richmond (1970) puts it:

> "....the equilibrium principle is closely related to the concept of readiness for learning. Readiness for this or that educational experience is another way of saying that the equilibrated structures can accommodate to a given experience... However, if intellectual activity is not best described by means of an equilibrium model, then this view of readiness will not stand".

If an alternative conceptions Programme succeeds in demonstrating a priori (i.e. using data analysis conducted without Piagetian expectations) that Piaget's 'epistemic subject' does not exist. then stratified access has no validity in science education. Furthermore, if it does not exist then a powerful and desirable progression will have been made and science education will be the more securely based.

JKG/DJS/MRR
JUNE, 1981

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